

# **SEDIMENT TRANSPORT BY MUD FLOWS AND TURBIDITY CURRENTS IN CONTINENTAL MARGINS**

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## **LONG TERM SCIENTIFIC GOAL**

The long-term scientific goal is to develop sound theoretical models for submarine sediment movement that can be used to predict both the initiation, spatial development, and time duration of mud flows and turbidity currents, as well as the characteristics of the sedimentary deposits that these flows generate in continental shelves and slopes.

## **SCIENTIFIC OBJECTIVES**

This research has two main components. The first component addresses the evolution of mud flows (i.e. dense gravity currents) on submarine slopes, with the goal of developing the capabilities to predict the velocity, thickness, and run-out distance of mud flows. The second component of the research involves experiments on non-channelized turbidity currents (i.e. dilute density currents) and the sediment deposits they generate. The main question here is with regards to the effect that the bed gradient has on the evolution and lateral spreading of turbidity currents on continental shelves and slopes and whether such slope-induced effect can be recognized in the sediment deposits generated by such flows. The main objectives are: 1) to study the effect of sediment discharge, sediment size and density, and bottom slope on the evolution of three-dimensional mud flows and turbidity currents "representative" of those expected to occur on continental shelves and slopes, and 2) to study the nature of the sediment deposits generated by three-dimensional turbidity currents and mud flows (e.g. thickness and particle size distribution in the vertical and horizontal directions).

**APPROACH** Mathematical models of mud and turbidity flows have been developed in tandem with laboratory experiments on non-channelized turbidity currents and their deposits. Large scale laboratory experiments provide important knowledge for testing and improving physically-based predictive models of turbidity currents and mud flows in nature. Model predictions will be compared with field observations of the sedimentary record and submarine channel morphology made in the realm of STRATAFORM.

## **WORK COMPLETED**

An analytical model was developed for two-dimensional, laminar, non-hydroplaning mud flows resulting from submarine slides. The model can be used both to predict the evolution of slides along continental slopes, and to interpret the deposits generated by them. An experimental tank has been constructed to generate three-dimensional sediment laden flows. The tank is deep enough to allow for the setting of an inclined bottom at different positions so as to cover the range of bottom gradients commonly observed in continental shelves and slopes. A set of experiments involving the release of a fixed amount of sediment and water has been completed. Experiments involving the formation of submarine channels similar to those observed along the continental slope near the Eel River mouth, were started.

## **RESULTS**

The analytical model can predict the asymptotic runout characteristics of submarine, non-hydroplaning mudflows. As an example, a hypothetical submarine slide on a slope of is considered. The initial sediment

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mass has a maximum thickness of 7.25m, a maximum length of 207.6 m, and a volume of 752.6. For a bulk density of 2.0, a kinematic viscosity of 0.005, and a yield stress of 200 , the propagating velocity of the flow front is predicted to be 2.3 m/s after about 30 seconds, and then to decrease along the flow path, producing a deposit 0.58 m thick and 1.3 km long. The final stage of the slide is similar to a creeping motion. Twelve experiments have been conducted on turbidity currents originated by the sudden release of a water-sediment mixture. The lateral and longitudinal spreadings as a function of time, observed with the help of a video camera, is shown in Figure 1. The characteristics of the sediment deposits created by such flow are shown in Figure 2. Therein the formation of a channel with levees can be clearly observed.

## **IMPACT AND APPLICATIONS**

The analytical solution obtained for mud flows provides a tool for both learning about the behavior of flows that can rarely be observed directly, and predicting the run-out distance of mud flows generated by submarine slope failures. It also gives a means to test more sophisticated sediment transport models. The laboratory experiments provide direct observations of three-dimensional flows which are very difficult to make in the field. The sediment deposits generated in the lab provide a litmus test for sedimentation models by turbidity currents in continental margins. The formation of submarine channels and bedforms by turbidity flows is being addressed for the first time in the laboratory and should provide important clues as to what are the mechanisms responsible for some of the features observed in the sedimentary record.

## **TRANSITIONS AND RELATED PROJECTS**

The modeling of continental margins requires tools that can be tested and calibrated against observations. This effort aims at providing STRATAFORM researchers with direct observations of mud flows and turbidity currents, with an emphasis on the sedimentological implications of such flows. More precisely, the work of J. Syvitski on hyperpycnal flows, G. Parker on debris flows, L. Pratson on slope failures and slides, H. Lee and J. Locat on slope stability, and M. Field, J. Gardner, and D. Prior on characteristics of deposits, will benefit from the large-scale laboratory experiments being conducted as part of this effort.

## **1997 PUBLICATIONS SUPPORTED BY ONR**

Huang, X., and Garcia, M.H., 1997. A perturbation solution for Bingham-plastic mud flows. *J. of Hydraulic Engineering, ASCE*, vol.123, N 11, Nov., 986-994.

Huang, X., and Garcia, M.H., 1997. Asymptotic solution for Bingham debris flows. *Proceedings of First International Conference on Debris Flow Hazards Mitigation*, C.L. Chen (Editor), ASCE, August, 561-575.

Huang, X., and Garcia, M.H., 1997. Modeling of non-hydroplaning mudflows on continental slopes. Submitted to *Marine Geology*, Special STRAFORM Issue.

Huang, X., and Garcia, M.H., 1997. Matched-asymptotic analysis of a two-dimensional, unsteady mudflow modeled as a Herschel-Bulkley fluid. Submitted to *Journal of Fluid Mechanics*.

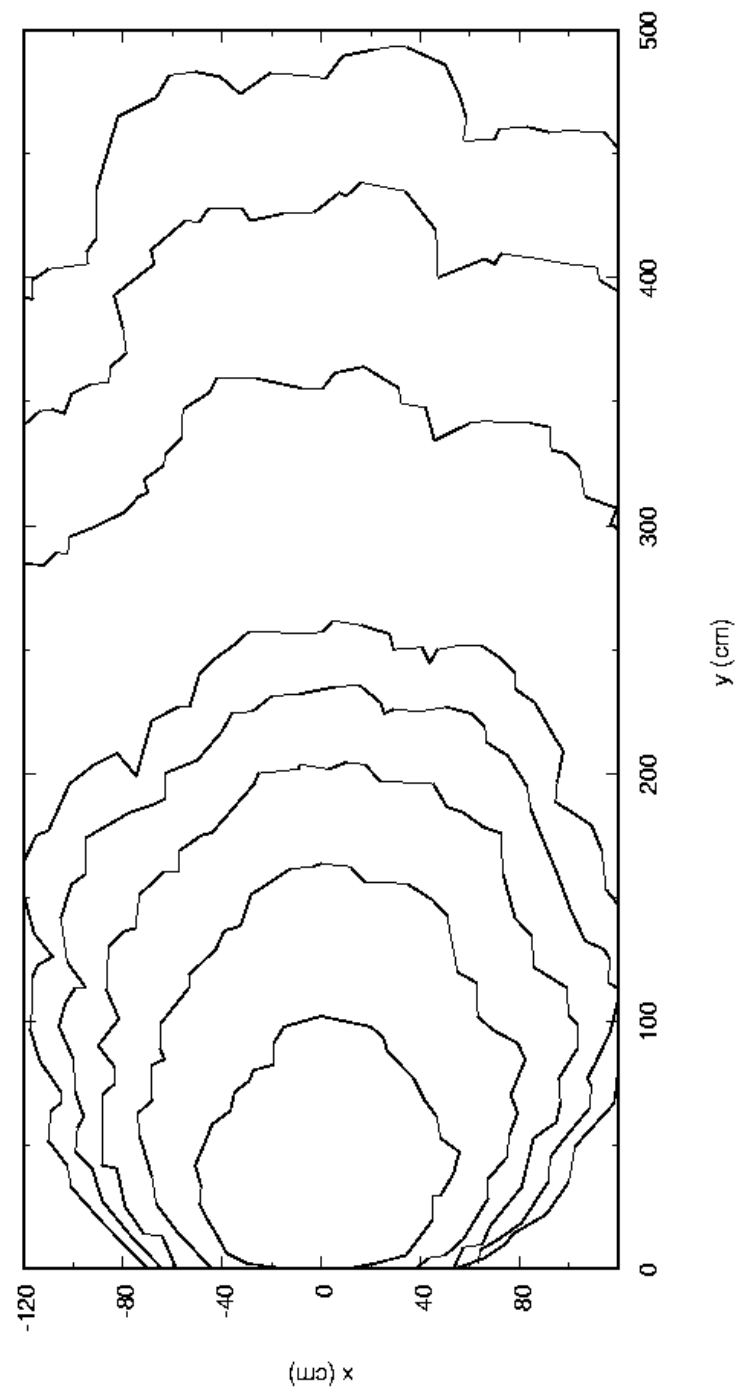


Fig. 1 Spreading Fronts at Time = 2, 4, 6, 8, 10, 20, 30, 40 sec.

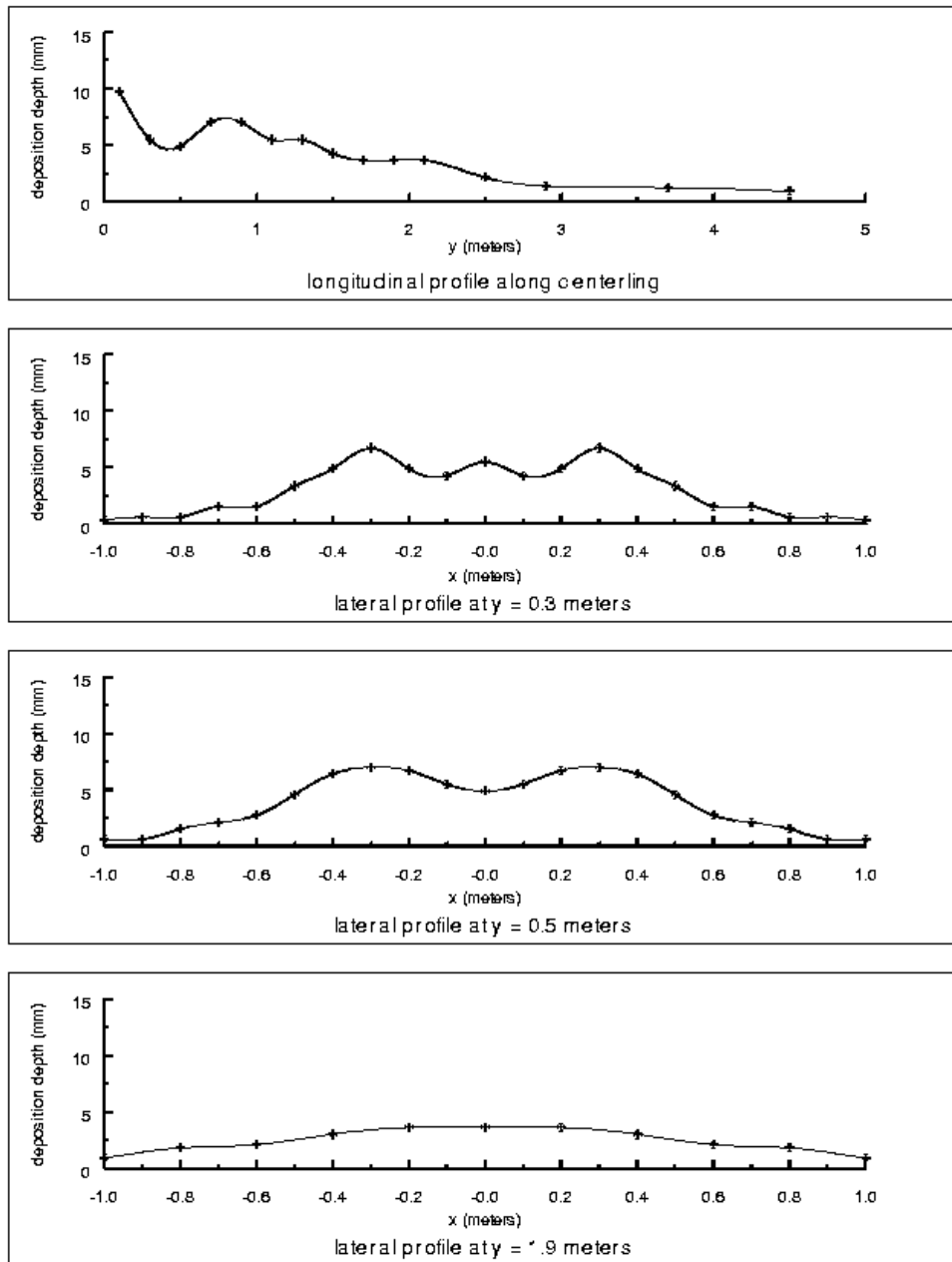


Fig. 2 Deposition Profiles After 5 Releases